Kingdom of Thailand

EDICT OF GOVERNMENT

In order to promote public education and public safety, equal justice for all, a better informed citizenry, the rule of law, world trade and world peace, this legal document is hereby made available on a noncommercial basis, as it is the right of all humans to know and speak the laws that govern them.

TIS 17-2532 (1989) (English): Unplasticized polyvinyl chloride pipes for drinking water services

BLANK PAGE

PROTECTED BY COPYRIGHT

Unofficial Translation

In the event of any doubt or misunderstanding arising from this translation, the standard in Thai will be held to be authoritative.

THAI INDUSTRIAL STANDARD FOR UNPLASTICIZED POLYVINYL CHLORIDE PIPES FOR DRINKING WATER SERVICES TIS 17-2532 (1989)

1. Scope

1.1 This standard specifies types, kinds and classes, sizes and tolerances, requirements, marking and labelling, sampling and criteria for conformity and testing for unplasticized polyvinyl chloride pipes for drinking water services suitable for use only in places not exposed to direct sunlight.

2. Definitions

For the purpose of this standard, the following definitions apply:

2.1 UNPLASTICIZED PVC PIPE hereinafter referred to as PIPE: An unplasticzed polyvinyl chloride pipe.

2.2 PIPE WITH PLAIN END : Pipe having uniform inside and outside diameters throughout the entire length.

2.3 PIPE WITH SOCKET : Pipe having one of its end serve as socket, made by heat fabricating plain end pipe.

2.4 SOCKET : The flared end of a pipe with socket.

2.5 HOOP STRESS or HYDROSTATIC DESIGNED STRESS : The circumferential stress used in calculation of pipe size for service at any given working pressure.

2.6 NOMINAL PRESSURE : The working pressure of the pipe specified for service at a temperature of 27 °C.

2.7 WORKING PRESSURE : The maximum pressure which the pipe can sustain in continuous use.

3. Types, kinds and classes

3.1 Pipes are of 2 types :

3.1.1 Pipe with plain end

3.1.2 Pipe with socket, classified into 2 kinds :

3.1.2.1 Pipe for solvent cement joint, as shown in Figure 1

3.1.2.2 Pipe for rubber ring joint, as shown in Figure 2

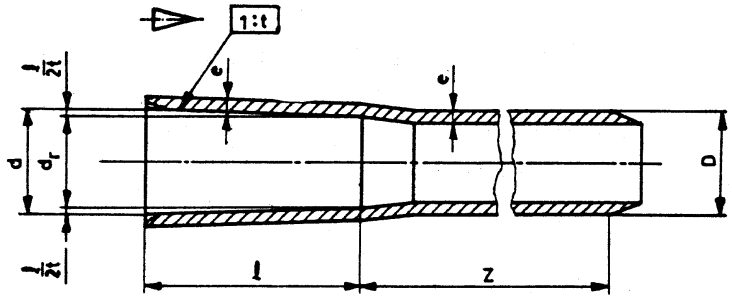


Figure 1 Pipe with socket for solvent cement jointing
(clause 3.1.2.1)

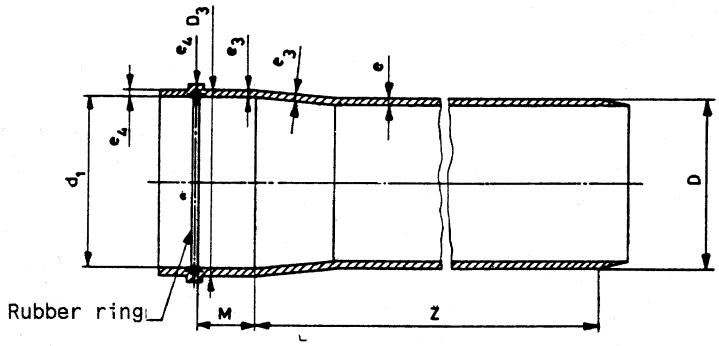


Figure 2 Pipe with socket for rubber ring jointing
(clause 3.1.2.2)

3.2 Pipes are classified by the nominal pressure into 3 classes as shown in Table 1.

Table 1
Classes of pipes
(clauses 3.2)

Class	Nominal pressure MPa
PVC 5	0.50
PVC 8.5	0.85
PVC 13.5	1.35

Note. 1 Mpa = 9.869 23 atm
= 10.197 2 kgf/cm^2
= 145.038 psi
= 101.97 16 mH_2O

4. Sizes and tolerances

4.1 Size designation, dimensions and tolerances of plain end pipes
Table 2 shall apply.
Measurement shall comply with clause 8.1.

4.2 Size designation, dimensions and tolerances of socket pipe for solvent cement and for rubber ring jointing
Table 3 and Table 4 shall apply, respectively.
Measurement shall comply with clause 8.1.

4.3 Out of roundness or ovality (not applicable to PVC 5 pipe)
The out-of-roundness shall not exceed $\pm$ 0.5% of the mean outside diameter.
Measurement shall comply with clause 8.1.

4.4 Length
The length of pipe shall be 4 m or as specified in the label, with a tolerance of not exceeding $^{+\ 30\ mm}_{0}$.
Measurement shall comply with clause 8.1.

5. Requirements

5.1 Workmanship
Pipes shall be straight, reasonably round and of uniform thickness. The internal and external surfaces of the pipe shall be smooth, clean and reasonably free from defects that would impair its performance in service. The ends shall be cleanly cut and square with the axis of the pipe.
Compliance is checked by visual inspection.

5.2 Heat reversion
When tested in accordance with clause 8.2, the average length shall not change by more than 5%.

5.3 Resistance to acetone
When tested in accordance with clause 8.3, the pipe shall show no fracture or disintegration. Flattening or swelling of the pipe shall not be deemed to constitute failure.

5.4 Resistance to sulfuric acid
When tested in accordance with clause 8.4, the weight of the specimen shall neither increase by more than 5% nor decrease by more than 0.1%.

Table 2
Size designation, dimensions and tolerances of plain end pipe
(clause 4.1)

Units in millimetres

Size designation	Mean outside diameter (D)	Thickness (e)		
		PVC 5	PVD 8.5	PVC 13.5
18	22 ± 0.15	-	2.0 ± 0.20	2.5 ± 0.20
20	26 ± 0.15	-	2.0 ± 0.20	2.5 ± 0.20
25	34 ± 0.15	-	2.0 ± 0.20	3.0 ± 0.25
35	42 ± 0.15	1.5 ± 0.15	2.0 ± 0.20	3.1 ± 0.25
40	48 ± 0.15	1.5 ± 0.15	2.3 ± 0.20	3.5 ± 0.25
55	60 ± 0.15	1.8 ± 0.20	2.9 ± 0.25	4.3 ± 0.30
65	76 ± 0.20	2.2 ± 0.20	3.5 ± 0.25	5.4 ± 0.35
80	89 ± 0.20	2.5 ± 0.20	4.1 ± 0.30	6.4 ± 0.40
100	114 ± 0.30	3.2 ± 0.25	5.2 ± 0.35	8.1 ± 0.50
125	140 ± 0.30	3.9 ± 0.30	6.4 ± 0.40	9.9 ± 0.55
150	165 ± 0.40	4.6 ± 0.30	7.5 ± 0.45	11.7 ± 0.65
200	216 ± 0.50	5.4 ± 0.35	8.8 ± 0.50	13.7 ± 0.75
250	267 ± 0.70	6.6 ± 0.40	10.9 ± 0.60	16.9 ± 0.90
300	318 ± 0.80	7.8 ± 0.45	12.9 ± 0.70	20.1 ± 1.05
350	370 ± 0.90	9.1 ± 0.55	15.0 ± 0.80	23.4 ± 1.20
400	420 ± 1.10	10.3 ± 0.60	17.0 ± 0.90	26.5 ± 1.35
450	470 ± 1.20	11.5 ± 0.65	19.0 ± 1.00	29.7 ± 1.50
500	520 ± 1.30	12.7 ± 0.70	21.0 ± 1.10	32.8 ± 1.65
600	630 ± 1.60	15.3 ± 0.80	25.4 ± 1.30	39.7 ± 2.00

Note. 1. Mean outside diameter (D) is calculated from the formula:

$$D = \frac{D_1 + D_2}{2}$$

$D_2 = D_1 + 0.005\ D_1$

or $= D_1 + 0.3$, whichever the greater

Where D_1 is minimum outside diameter, mm
D_2 is maximum outside diameter, mm

2. Thickness (e) is calculated from the formula:

$$e = \frac{e_1 + e_2}{2}$$

$$e_1 = \frac{PD_1}{2S + P}$$ but not less than 1.3 mm

$e_2 = 1.1\ e_1 + 0.2$ mm

Where e_1 is minimum pipe thickness, mm
e_2 is maximum pipe thickness, mm
P is working pressure at 20°C, MPa
S is maximum hoop stress = 11 Mpa for pipes smaller than size 200 and = 12.3 MPa for size 200 and over (value at 20°C)

Table 3
Size designation, dimensions and tolerances of socket pipes
(solvent cement jointing)
(clause 4.1)

Units in millimetres

Size designation	d	d_r	D, e	ℓ		1/t	Z
				min	max		min
18	22.4 ± 0.2	21.4 ± 0.3	As given in Table 2 for all 3 classes	30	35	1/34	3 945
20	26.4 ± 0.2	25.3 ± 0.3		35	40	1/34	3 940
25	34.6 ± 0.2	33.3 ± 0.3		41	46	1/34	3 935
35	42.6 ± 0.2	41.2 ± 0.3		46	51	1/34	3 930
40	48.7 ± 0.3	47.2 ± 0.4		55	60	1/37	3 920
55	60.8 ± 0.3	59.0 ± 0.4		63	68	1/37	3 910
65	76.6 ± 0.3	75.2 ± 0.4		63	68	1/48	3 910
80	89.6 ± 0.3	88.2 ± 0.4		64	69	1/49	3 905
100	114.7 ± 0.3	113.2 ± 0.4		84	89	1/56	3 885
125	140.8 ± 0.4	139.0 ± 0.4		104	109	1/58	3 860
150	166.0 ± 0.4	163.9 ± 0.4		132	137	1/63	3 830
200	217.9 ± 0.8	213.8 ± 0.9		200	210	1/50	3 750
250	269.3 ± 0.9	264.2 ± 1.0		250	260	1/50	3 700
300	320.7 ± 1.0	314.6 ± 1.1		300	310	1/50	3 645
350	373.1 ± 1.0	366.0 ± 1.1		350	360	1/50	3 595
400	423.6 ± 1.2	415.5 ± 1.3		400	410	1/50	3 540
450	474.0 ± 1.2	464.9 ± 1.3		450	460	1/50	3 490
500	524.5 ± 1.3	514.4 ± 1.4		500	510	1/50	3 435
600	635.3 ± 2.1	623.3 ± 2.2		600	610	1/50	3 330

Note. 1. Socket may be made as shown by the dotted line in Figure 1.
2. 1/t is given as recommendation.
3. Z is the length of socket pipe for solvent cement jointing made from 4000 mm long plain end pipes, for those made from plain end pipes of other lengths, the length is calculated as follows:

Length of socket pipe for solvent cement jointing, min, in mm
= Z + (length of plain end pipe used – 4000)

Table 4
Size designation, dimensions and tolerances of socket pipes
(rubber ring jointing)
(clause 4.2)

Units in millimetres

Size designtion	D_1	D, e	e_3 min			e_4 min			M
	min		PVC 5	PVC 8.5	PVC 13.5	PVC 5	PVC 8.5	PVC 13.5	min
55	60.40	As given in Table 2 for all 3 classes	1.65	2.85	4.65	1.45	2.40	3.60	38
65	76.40		2.10	3.60	5.90	1.80	2.95	4.55	41
80	89.50		2.45	4.20	6.90	2.10	3.45	5.40	44
100	114.50		3.10	5.35	8.80	2.70	4.40	6.85	50
125	140.60		3.85	6.55	10.80	3.25	5.40	8.45	55
150	165.70		4.50	7.75	12.75	3.90	6.35	9.95	61
200	216.90		5.25	9.00	14.80	4.55	7.50	11.70	72
250	268.10		6.50	11.15	18.30	5.60	9.30	14.40	84
300	319.30		7.75	13.25	21.80	6.65	11.00	17.15	84
350	371.50		9.00	15.45	25.35	7.70	12.80	20.00	90
400	421.70		10.20	17.50	28.80	8.75	14.50	22.65	98
450	471.90		11.40	19.60	32.20	9.80	16.20	25.40	105
500	522.10		12.65	21.70	35.65	10.80	17.95	28.05	113
600	633.80		15.35	26.30	43.25	13.05	21.70	33.95	129

Note. 1. For socket pipes for rubber ring jointing not exceeding 6 m in length , the socket depth (M) as given in Table 4 shall apply.
For longer pipes, the minimum value of M shall be calculated from the formula:
$M = CTZ + 0.22\ d_1$ for pipe size not exceeding 250
$M = 1.4\ CTZ + 0.15\ d_1$ for pipe size greater than 250
Where C is the coefficient of linear expansion = 8.1×10^{-5} mm/mm/°C
T is the difference in service temperature = 50°C
Z is the length of socket pipe for rubber ring jointing, mm
d_1 is the minimum inside diameter of the socket, mm

2. If the calculated value of M of socket pipe size 300 is smaller than that of size 250, the respective value of size 250 shall also apply for size 300.

3. The shape of socket and rubber ring given in Figure 2 is provided as example.

4. e_3 is calculated from the formula:

$$e_3 = \frac{PD_3}{2S + P}$$ but not less than the minimum thickness of plain end pipe

$D_3 = d_1 + 2e_3$
Where P is the working pressure at 20°C, Mpa
D_3 is the maximum outside diameter of socket, mm
S is the minimum hoop stress = 11 Mpa for pipe size smaller than 200 and = 12.3 MPa for pipe size 200 and over (value at 20 °C)

5. e_4 is calculated from the formula:
$e_4 = 0.9\ e_1$
Where e_1 is the minimum thickness of plain end pipe as given in Table 2.

5.5 Opacity
When tested in accordance with clause 8.5, the wall of the pipe shall not transmit more than 0.2 % of the visible light falling on to it.

5.6 Effect on water
The pipe shall not impart to water any odour, taste, colour or any toxic constituents in concentrations that could be injurious to health. When tested in accordance with Appendix A, the quantities of lead, dialkyl tin C_4 and higher homologes and cadmium extracted shall not exceed those specified in Table 5.

Table 5
Quantities of toxic substances
(clause 5.6)

Toxic substance	Quantity, mg/kg	
	1st extraction	3rd extraction
Lead	1.0	0.3
Dialky tin C_4 and higher homologues measured as tin	-	0.02
Cadmium	-	0.01

5.7 Resistance to compression
When tested in accordance with clause 8.6, the pipe shall show no signs of cracking, splitting or fracture.

5.8 Impact resistance
When tested in accordance with clause 8.7, the pipe shall show no signs of cracking or puncture.

5.9 Short term hydrostatic pressure resistance
When tested in accordance with clause 8.8, the pipe shall withstand, without showing signs of leakage or cracking, the pressure as prescribed in Table 6.

5.10 Leakproofness of socket for rubber ring jointing
When tested in accordance with clause 8.9, the socket area shall show no sign of leakage.

Table 6
Short-term hydrostatic pressure
(clauses 5.9 ans 8.8.4.1)

Size designation	Short term hydrostatic pressure, MPa		
	PVC 5	PVC 8.5	PVC 13.5
18	-	6.20	8.13
20	-	5.18	6.76
25	-	3.89	6.13
35	1.80	3.06	4.86
40	1.80	3.06	4.86
55	1.80	3.06	4.86
65	1.80	3.06	4.86
80	1.80	3.06	4.86
100	1.80	3.06	4.86
125	1.80	3.06	4.86
150	1.80	3.06	4.86
200	1.80	3.06	4.86
250	1.80	3.06	4.86
300	1.80	3.06	4.86
350	1.80	3.06	4.86
400	1.80	3.06	4.86
450	1.80	3.06	4.86
500	1.80	3.06	4.86
600	1.80	3.06	4.86

5.11 Short term hydrostatic pressure resistance of socket
When tested in accordance with clause 8.10, the socket area shall show no sign of leakage.

5.12 Long term hydrostatic pressure resistance
When tested in accordance with clause 8.11, the extrapolated 50 year circumferential stress shall be not less than the value given in Table 7.

Table 7
Minimum 50 year circumferential stress
(clarse 5.12)

Size Designation	Minimum 50 year stress MPa
18 up to 50	18.54
200 up above	21.48

6. Marking and labelling

6.1 The colour of the pipe shall be blue (arctic blue conforming to BS 381 C).

6.2 Each section of pipe shall bear at least number, letter or mark indicating clearly and permanently the following information:

1) The term “Pipe for drinking water services”
2) Size designation
3) Class
4) Length in metres (except if = 4 m)
5) Year of manufacture
6) Name of manufacturer of factory, or registered trade mark

In case foreign language is used, the meaning shall correspond to that in Thai specified above.

Note : In marking with the information items (2) and (3), the size designation shall be indicated supplemented by the class of pipe, e.g. 18 PVC 5 refers to the pipe of nominal size 18 and nominal pressure 0.5 MPa.

6.3 Any person who manufactures product complying with this standard may use the Standards Mark in connection with his product only after having received a license from the Industrial Product Standards Council.

7. Sampling and criteria for conformity

7.1 Lot in this standard refers to pipes of the same type, king and class made by the same process at the same period of time.

7.2 Sampling and acceptance shall comply with the sampling plan specified below or with any other technically equivalent plan.

7.2.1 Sampling and acceptance for dimensional inspection

7.2.1.1 Samples shall be drawn at random from pipes of the same size designation in quantities as given in Table 8.

7.2.1.2 Criteria for conformity

Provided the number of samples failing to comply with each of the requirements of clause 4.1 or 4.2, clause 4.3 and clause 4.4 does not exceed the acceptance number given in Table 8, the lot shall be deemed to pass the test requirements.

Table 8
Sampling plan for dimensional inspection
(clause 7.2.1)

Lot size Sections	Sample size sections		Acceptance number
	Plain end	Socket end	
UP to 1 200	3	2	0
1 201 to 3 200	13	8	1
3 201 to 35 000	20	13	2
Over 35 000	32	20	3

7.2.2 Sampling and acceptance for tests on workmanship, heat reversion, resistance to acetone, resistance to sulfuric acid, resistance to compression, impact resistance, short term hydrostatic pressure resistance, leakproofness of socket for fubber ring jointing, short term hydrostatic pressure resistance of socket

7.2.2.1 Samples shall be drawn at random from pipes of the same lot and size designation in quantities given in Table 9.

7.2.2.2 Provided the number of samples failing to comply with each of the requirements of clauses 5.1, 5.2, 5.3, 5.4, 5.7, 5.8, 5.9, 5.10 and 5.11, does not exceed the acceptance number given in Table 9, the lot shall be deemed to pass the test requirements.

Table 9
Sampling plan for tests on workmanship, heat reversion, resistance to acetone, resistance to sulfuric acid, resistance to compression, impact resistance, short term hydrostatic pressure resistance, leakproofness of socket for rubber ring jointing and short term hydrostatic pressure resistance of socket.
(clause 7.2.2)

Lot size Sections	Sample size Sections	Acceptance Number
UP to 1 200	2	0
1 201 to 3 200	8	1
3 201 to 35 000	13	2
Over 35 000	20	3

7.2.3 Sampling and acceptance for tests on opacity and effect on water

7.2.3.1 Three sections of pipes shall be drawn at random from pipes of the same lot and of the same size designation.

7.2.3.2 Provided all samples meet the requirements of clause 5.5 and 5.6, that lot shall be deemed to pass the test.

7.2.4 Sampling and acceptance for test on long-term hydrostatic pressure resistance

7.2.4.1 Samples shall be drawn at random from pipes of the same lot as follows:

(1) For sizes 18 to 150, samples shall be taken from 2 size designations, except when such lot contains only one size where the samples shall be taken from one size designation;

(2) For size 200 and larger, samples shall be taken from one size designation;

In quantities as given in Table 10. From each of these samples, not more than 2 test specimens shall be prepared and placed in separate groups in quantities as required in Table 10.

7.2.4.2 Sizes 18 to 150

(1) Provided the requirement of clause 5.12 is met for the two selected sizes, that lot shall be deemed to comply with the requirement.

Table 10
Sampling plan for test on long term hydrostatic pressure resistance
(clause 7.2.4)

Sample size per size designation sections	Number of test specimens per size designation	
	Group 1	Group 2, min.
5	5	2

(2) If the requirement of clause 5.12 is met only for one size, new samples of the size that has failed shall be taken together with those of 2 other sizes, representing in all there sizes. Form each of these samples, one test specimen shall be prepared to the requirement of Table 10. All three sizes must meet the requirement of clause 5.12 for the lot to be deemed in compliance with the requirement.

7.2.4.3 Size designation 200 and larger

(1) Provided the requirement of clause 5.12 is met, that lot shall be deemed to comply with the requirement.

(2) If the requirement of clause 5.12 is not met, new samples of the size that has failed shall be taken together with those of one additional size, representing in all two sizes. From each of these samples, one test specimen shall be prepared to the requirement of Table 10. All two sizes must pass the requirement of clause 5.12 for the lot to be deemed in compliance with the requirement.

7.3 Provided the requirements of all of clause 7.2.1.2, clause 7.2.2.2, clause 7.2.3.2 and clause 7.2.4.2 or 7.2.4.3 are met, that lot shall be deemed to comply with this standard.

8. Tests

8.1 Sizes

8.1.1 Outside diameter

8.1.1.1 Apparatus

A micrometer, a vernier caliper or any suitable measuring device accurate to within 0.05 mm

8.1.1.2 Procedure

Measure the outside diameter of pipe at the point of maximum value on a circumference and then measure the minimum diameter at right angles to the maximum diameter.

The average of the two measurements shall be taken as the mean outside diameter of pipe.

8.1.2 Inside diameter of socket pipe for solvent cement jointing

8.1.2.1 Inside diameter of socket at end (d)

(1) Apparatus

A vernier caliper or any suitable measuring device accurate to within 0.05 mm

(2) Procedure

Measure the socket inside diameter at 4 places on the socket end positioned at about 45° from each other. The average of the 4 readings shall be determined and taken as the inside diameter of the socket at end.

8.1.2.2 Inside diameter of socket at root (d_r)

(1) Apparatus

A vernier caliper or any suitable measuring device accurate to within 0.05 mm

(2) Procedure

Measure the socket inside diameter at 4 places on the socket root positioned at about 45° from each other. The average of the 4 readings shall be determined and taken as the inside diameter of the socket at root.

8.1.3 Thickness

8.1.3.1 Apparatus

A ball micrometer (of 3 mm diameter) of 0.01 mm accuracy or any suitable apparatus of the specified accuracy

8.1.3.2 Procedure

Measure the wall thickness, at least at 6 places on a circumference, and report the maximum and the minimum readings.

8.1.4 Out-of-roundness

The Out-of-roundness shall be calculated from the following formula:

Out-of roundness, %

$$= \frac{\text{Outside diameter (max or min)} - \text{Mean outside diameter}}{\text{Mean outside diameter}} \times 100$$

8.1.5 Length

8.1.5.1 Apparatus

A metal measuring tape accurate to within 1 mm

8.1.5.2 Procedure

Measure the length of the pipe which is laid straight on a level surface.

8.2 Heat reversion

8.2.1 Apparatus (see Figure 3)

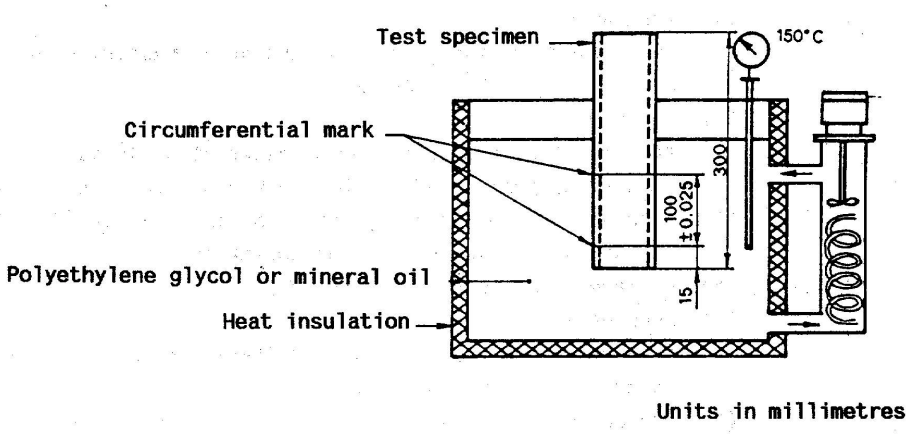


Figure 3 Apparatus for heat reversion test
(clause 8.2.1)

8.2.1.1 A bath of polyethylene glycol, or mineral oil free from aromatic hydrocarbons

8.2.1.2 An apparatus for controlling the temperature of the liquid in the bath

8.2.2 Preparation of test specimens

The test specimen shall consist of a length of pipe approximately 300 mm long. Two circumferential marks shall be scribed on the test specimen 100 mm apart and in such a way that one of these marks is approximately 15 mm from one end of the specimen.

8.2.3 Procedure

8.2.3.1 The temperature of the heat transfer medium shall be maintained at 150 ± 2°C.

8.2.3.2 The specimens shall be suspended vertically and immersed in the heat transfer medium for 15 minutes for pipe of wall thickness not greater than 8.1 mm, or 30 minutes for larger pipe in such a way that both scribed marks are completely immersed. Care shall be taken to ensure that the specimen does not contact the sides or bottom of the bath.

8.2.3.3 After the specified immersion period, the specimen shall be removed from the bath and allowed to cool to room temperature. The distance between the two scribed marks shall be measured at four places spaced apart from each other at a distance of approximately 1/4 of the pipe circumference.

8.2.3.4 The percentage change in length shall be calculated.

8.3 Resistance to acetone

8.3.1 Apparatus

8.3.1.1 Containers with covers

8.3.1.2 Anhydrous acetone

8.3.2 Preparation of test specimens

8.3.2.1 The test specimen shall be of such length convenient for the test.

8.3.3 Procedure

8.3.3.1 One specimen shall be placed in each of the containers of clause 8.3.1.1 into which anhydrous acetone shall be poured until it covers the specimen. Cover the containers tightly and keep at room temperature for 2 hours.

8.3.3.2 After the specified immersion period, the specimens shall be removed and inspected on the outside, inside and section surfaces.

8.4 Resistance to sulfuric acid

8.4.1 Apparatus

8.4.1.1 A container containing sulfuric acid of 17.3 Mole/dm^3 concentration, and cover

8.4.1.2 An apparatus capable of controlling the temperature of sulfuric acid to within ± 2°C of the specified temperature

8.4.1.3 A weighing device accurate 0.001 g

8.4.2 Preparation of test specimens

8.4.2.1 The test specimen shall have a total surface area of 45 ± 3 cm^2.

8.4.3 Procedure

8.4.3.1 The temperature of the sulfuric acid shall be controlled at 55 ± 2°C.

8.4.3.2 The test specimen shall be cleaned, wiped dry and weighed, then totally immersed in the sulfuric acid for 14 days.

8.4.3.3 After the specified immersion period, the specimen shall be removed, washed in running water for 5 minutes, wiped dry with a clean cloth and reweighed immediately. The percentage change in weight shall be calculated.

8.5 Opacity

8.5.1 Apparatus

The test apparatus consists of an electric lamp, a photovoltaic cell and a spot light galvanometer or other suitable photometric apparatus.

8.5.2 Preparation of test specimens

The test specimen shall be machined to a thickness of 1.25 ± 0.05 mm and shall be of a size that will cover the photovoltaic cell. The specimen shall be heated and then flattened.

8.5.3 Procedure

8.5.3.1 The light source and photovoltaic cell shall be set up at a convenient distance apart in the absence of daylight or in the dark room.

8.5.3.2 The deflection of the galvanometer shall be noted. A test specimen shall then be placed over the photovoltaic cell, the distance between source and cell being kept constant. The deflection of the galvanometer shall again be noted.

8.5.3.3 The second deflection shall be expressed as percentage of the first.

8.6 Resistance to compression

8.6.1 Preparation of test specimens

The test specimen shall be approximately 50 mm long.

8.6.2 Procedure

8.6.2.1 The test specimen shall be compressed between 2 parallel metal plates at uniform rate until the distance between the plates is 40% of the outside diameter of the specimen. The test shall be completed within 5 minutes.

8.6.2.2 After the test, observe if cracks, fracture or breakage results.

8.7 Impact resistance

8.7.1 Apparatus

A falling weight machine as shown in Figure 4 which consists essentially of the following:

8.7.1.1 A main frame, rigidly fixed in the true vertical position

8.7.1.2 A weight striker which can fall freely within the guide rails and which is equipped with a hardened hemisperical striking surface of 12.5 ± 0.05 mm diameter. The striking surface shall be smooth and free from imperfections.

8.7.1.3 An appropriate set of weight which can be firmly attached to the striker to enable the combined mass of striker and weight to be adjusted to the values given in Table 11.

8.7.1.4 A specimen support comprising a 120° V-block at least 300 mm in length which is positioned below the guide rails so that the tip of the striker is not more than 2.5 mm from the axis of the block. This specimen support shall be rigidly secured to the base. The surfaces of the V-block shall be of sufficient width such that the distance from the point of contact to the upper edge shall not be less than 75 mm. After installation, the surfaces of the V-block shall make 60° angle to the vertical axis.

8.7.1.5 A holding device to hold the weighted striker at the specified distance above the specimen within the range 2 000 ± 10 mm measured from the bottom of the striking surface of the top of the specimen. The holding device shall incorporate a release mechanism to allow the striker to fall freely in the guides, striking the test specimen in a reproducible manner.

8.7.2 Preparation of test specimens

8.7.2.1 The specimen shall be of a length equal to twice the outside diameter or 150 mm, whichever is the greater, subject to a maximum length of 300 mm. The ends of the specimen shall be cut clean and square to the axis of the pipe.

8.7.2.2 The specimen shall be conditioned for at least 2 hours in a water bath maintained at a temperature of 27 ± 1°C and tested immediately after removal from the bath.

8.7.3 Procedure

8.7.3.1 The mass of the striker shall be adjusted to the value appropriate to the size of the specimen as shown in Table 11. The striker shall be positioned such that its tip is 2 000 ± 10 mm from the top surface of the test specimen regardless of the size of the specimen.

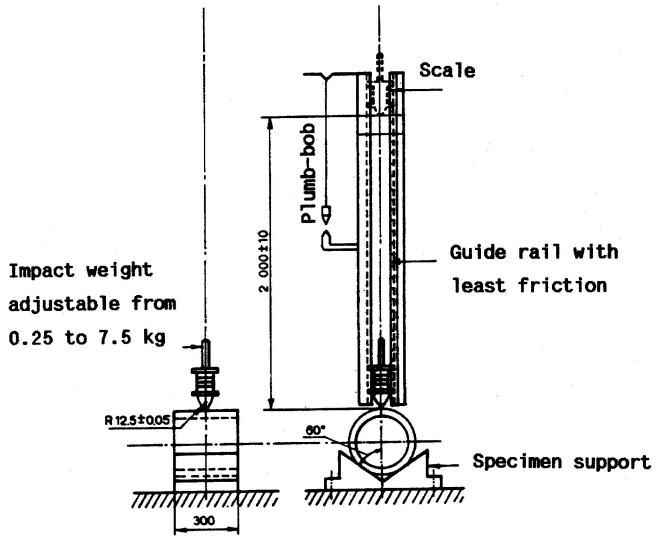


Figure 4 Typical impact apparatus
(clause 8.7.1)

8.7.3.2 The striker shall be allowed to fall freely on the specimen which is centrally mounted on the support.

8.7.3.3 After test, examine the specimen for fracture, cracks and puncture.

8.8 Short term hydrostatic pressure resistance

8.8.1 Test conditions

The test specimens shall be conditioned in the bath maintained at 27 ± 1°C for a period of not less than 2 hours and then tested while immersed in the bath. Test may be conducted in air provided the ambient temperature is maintained at 27 ± 1°C.

Table 11
Weight of striker
(clauses 8.7.1.3 and 8.7.3.1)

Outside diameter mm	Weight of Striker Kg	Outside diameter mm	Weight of striker kg
22	0.75	89	2.25
26	1.00	114	2.75
34	1.25	140	3.25
42	1.38	165	3.75
48	1.50	216	5.00
60	1.75	267	6.25
76	2.00	≥ 318	7.50

8.8.2 Apparatus
Equipment that permits the application of a controlled internal hydraulic pressure of not less than 9 MPa to the specimen and capable of maintaining an accuracy of 2 %.

8.8.3 Preparation of test specimens
The test specimen shall be of a length between fittings equal to 10 times the outside diameter of the pipe, subject to a minimum of 250 mm and a maximum of 750 mm. For pipes of designated size 350 and greater, the test specimen shall be not less than 1 000 mm long (see mounting in Figure 5).

8.8.4 Procedure

8.8.4.1 The specimen shall be connected to the apparatus as in Figure 5, filled with water ensuring that all air is excluded. The pressure as specified in Table 6 shall be applied at uniform rate and achieved within 40 seconds. Maintain this pressure for 1 hour.

8.8.4.2 At completion of test, inspect the specimen for leakage or cracking failures.

8.9 Leakproofness of socket for rubber ring jointing

8.9.1 Apparatus
The apparatus used shall be as given in clause 8.8.2.

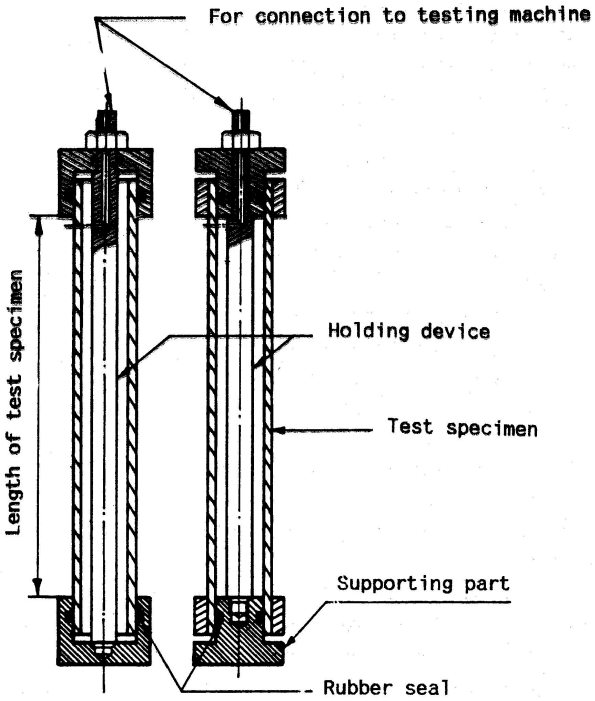
8.9.2 Preparation of test specimens
The sample shall be cut into two sections and rejointed in following the manufacturer's instructions (using preferable rubber ring complying with ASTM F 477); this shall constitute one test specimen. The length of each test specimen shall be not less than 1 000 mm. For pipe size 350 and over, the length of the specimen shall be not less than 3 times the outside diameter of the pipe.

8.9.3 Procedure

8.9.3.1 Leakproofness at horizontal plane (see Figure 6)

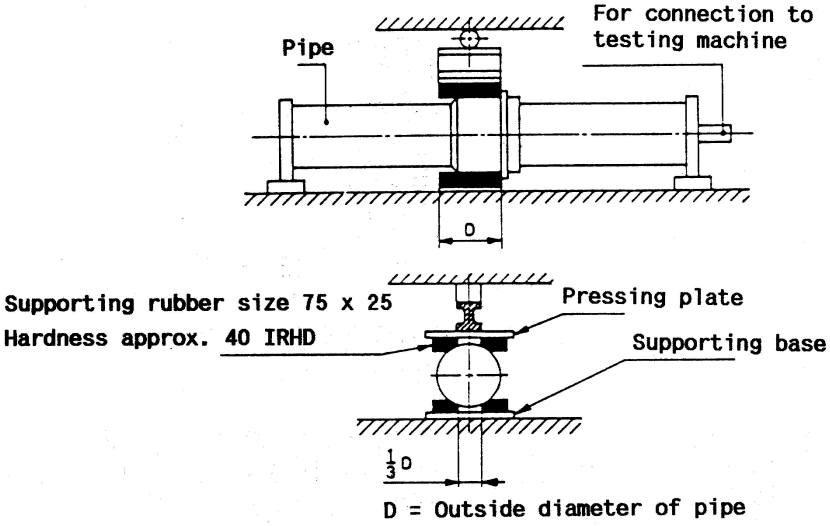
(1) The test specimen shall be filled with water, ensuring that all air is excluded. The water pressure equal to 300 mmH_2O shall then be applied to the specimen for 2 minutes, after which the socket area shall be inspected for leakage.

(2) Thereafter, the water pressure shall be applied at a uniform rate so as to achieve within 1 minute the test pressure equal to two times the service pressure at 27°C as specified in Table 12 which shall be maintained for 30 seconds. The socket area shall be inspected for leakage.



Units in millimetres

Figure 5 Example for connection to testing machine
(clauses 8.8.3, 8.8.4.1 and 8.10.2.1)



Units in millimetres

Figure 6 Leakproofness test at horizontal plane
(clause 8.9.3.1)

Table 12
Working pressure at given temperatures
(clause 8.9.3.1 (2))

Working temperature, °C	Working pressure, MPa		
	PVC 5	PVC 8.5	PVC 13.5
20	0.58	0.98	1.57
27	0.50	0.85	1.35
30	0.47	0.79	1.25
40	0.35	0.59	0.94
50	0.23	0.39	0.62
60	0.12	0.20	0.31

8.9.3.2 Leakproofness after flattening as in Figure 7
Position the test specimen in a horizontal plane and apply a load at a distance of about 10 mm from the pipe end so that the pipe is flattened by 10% of the pipe outside diameter as measured between the parallel pressing plates. Conduct the test as in clause 8.9.3.1(2).

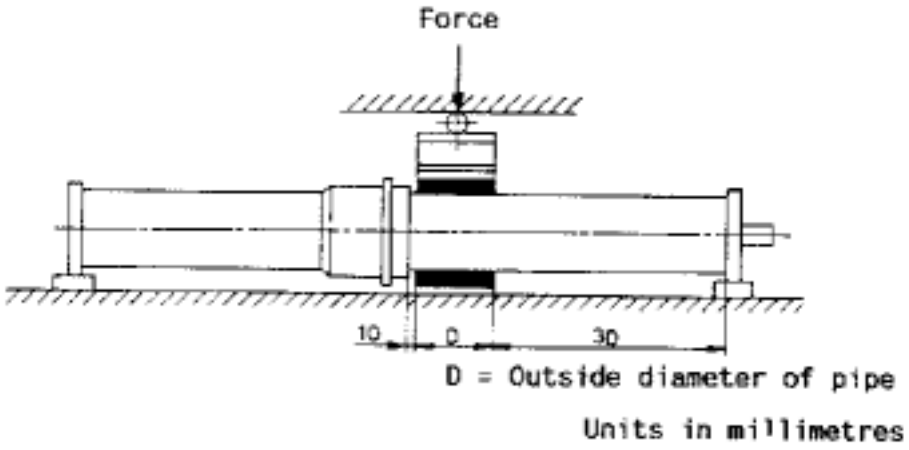


Figure 7 Leakproofness test after flattening
(clause 8.9.3.2)

8.9.3.3 Leakproofness at non-horizontal plane as in Figure 8
Position the test specimen at 3°C from the horizontal plane. Fill the test specimen with water ensuring that all air is excluded and conduct the test as in clause 8.9.3.1(2).

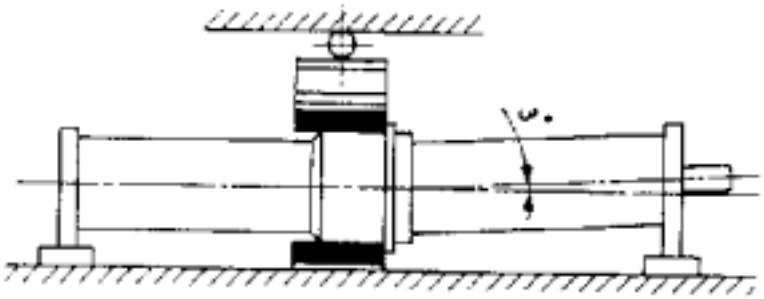


Figure 8 Leakproofness test at non-horizontal plane
(clause 8.9.3.3)

8.10 Short term hydrostatic pressure resistance of socket

8.10.1 Apparatus

The apparatus shall be a given in clause 8.8.2.

8.10.2 Preparation of test specimens

8.10.2.1 Socket pipe for solvent cement jointing

The sample shall be cut into two sections and rejointed in following the manufacturer's instructions; this shall constitute one test specimen. The length of each test specimen excluding end for connection to testing machine shall be approximately 10 times the outside diameter and not less than 250 mm nor more than 750 mm. For pipe size 350 and over the test specimen shall be not less than 1000 mm long.

(See mounting in Figure 5.)

8.10.2.2 Socket pipe for rubber ring jointing

The sample shall be cut into two sections and rejointed in following the manufacturer's instructions (using preferable rubber ring complying with ASTM F 477); this shall constitute one test specimen. The length of each test specimen excluding end for connection to testing machine shall be approximately 10 time the outside diameter and not less than 250 mm nor more than 750 mm. For pipe size 350 and over the test specimen shall be not less than 1000 mm long.

Note: In cutting the test specimen to the required length, care should be taken to ensure that the socket end is located near the pressure cap (as in Figure 9) to help prevent slipping of the rubber ring.

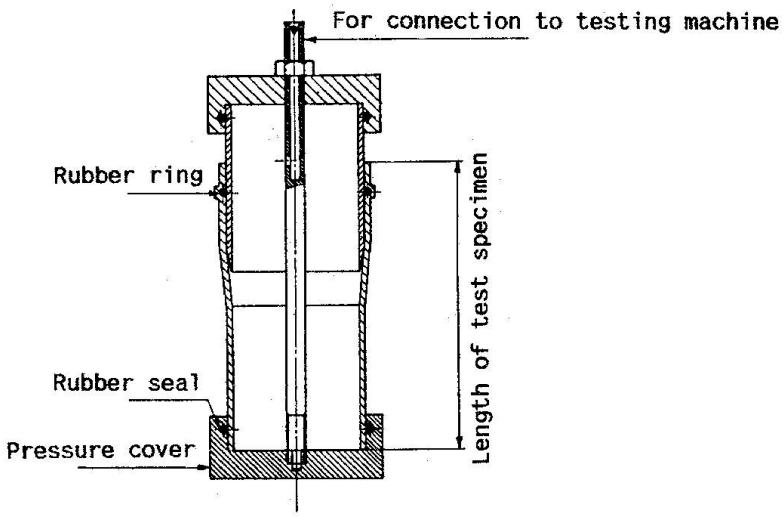


Figure 9 Preparation of test specimens of socket pipe
for rubber ring jointing
(clause 8.10.2.2)

8.10.3 Procedure

Conduct the test as in clause 8.8.4.1 and inspect the socket area for signs of leakage.

Note. 1. This test is to determine the pressure resistance of the socket. If during the test, the rubber ring slips out from the socket, replace the rubber ring and continue the test.

2. As the technical requirements of the short term hydrostatic tests for the socket and for the pipe in this standard are the same, the two tests may be conducted at the same time.

8.11 Long term hydrostatic pressure resistance

8.11.1 Test conditions

The test conditions shall be as specified in clause 8.8.1.

8.11.2 Apparatus

The apparatus shall be as specified in clause 8.8.2.

8.11.3 Preparation of test specimens

The preparation of the test specimens shall be as in clause 8.8.3.

8.11.4 Procedure

8.11.4.1 Conduct test on the first set of specimens cut from each sample. The first test specimen shall be tested as described in clause 8.8.4.1 to failure. Record the pressure at failure.

8.11.4.2 The second test specimen of the first set shall then be tested using lower pressure than in clause 8.11.4.1 which shall be maintained constant. If the test specimen bursts within a period of 1 to 10 hours, record the time and pressure. Otherwise, the pressure applied shall be increased between the first and the second reading such that the specimen bursts within 1 to 10 hours. After the pressure is known, the remaining specimens shall be tested and pressures so chosen that they burst within 1 to 10 hours.

8.11.4.3 The results of the test specimens shall be entered on a log (pressure) vs log (time) graph.

8.11.4.4 The results accumulated shall be subjected to a regression analysis periodically so as to obtain representative extrapolated 100 hour and 1000 hour stress levels. Obtain at least 2 values of pressure between the 100 hour and 1000 hour stress set. Record the pressure and time to failure, and enter the results on a new log graph.

8.11.4.5 Form the graph of clause 8.11.4.4, obtain representative extrapolated 50 year stress level and calculate the 50 year bursting stress using the formula:

$$S = \frac{P(D - e_1)}{2e_1}$$

Where S is the 50 year hoop stress, MPa
P is the 50 year bursting stress (obtained from graph), MPa
D is the mean outside diameter of test specimen, mm
e_1 is the minimum wall thickness, mm

Appendix A
Test for effect on water
(clause 5.6)

A.1 Reagents and preparation

A.1.1 A fresh solution of distilled water containing 150 mg/cm^3 carbon dioxide prepared by saturating a quantity of distilled water with carbon dioxide. The content of carbon dioxide shall be determined by the standard method. A fresh solution should be prepared for each series of tests.

Note. The standard method for the determination of carbon dioxide content shall comply with the Standard Methods for Examinations of Water and Waste Water, 16th edition (1985), prepared and published jointly by American Public Health Association, American Waterworks Association and Water Pollution Control Federation.

A.2 Preparation of test specimens

The specimens shall be 500 mm long cut from the pipe samples.

A.3 Preparation of test specimens

A.3.1 The specimens shall be fitted at one end with a cock and clamped in a vertical position to a stand with the stoppered end downwards. Tap water shall be poured into each pipe until it overflows slightly. Then the cocks shall be opened just sufficiently for a velocity of 3 m/min to be maintained inside the pipe for 6 hours while sufficient water is added to cause it to overflow at all time. The stopper shall then be removed and the interior of the pipes rinsed with distilled water. To reduce the quantity of washing water required, each pipe may be fitted with a smaller non-interfering core.

A.3.2 After the specimens have been cleaned, close one end of each specimen tightly with a plug made of polyethylene or other material that does not contain any toxic substances nor interfere with the test. Fill each pipe with the solution as of clause A.1.1 and close the other end of the pipe with a plug of the same sort.

A.3.3 Maintain the pipes at room temperature for 48 hours. Retain the extractant for the determination of the amounts of lead present after the first extraction.

A.3.4 Repeat the procedure as in clauses A.3.2 and A.3.3 twice on each specimen and retain the extractant after the third extraction for the determination of the amount of lead (as in clause A.4.1), tin (as in clause A.4.2) and cadmium (as in clause A.4.3).

A.4 Determination of content of lead, tin and cadmium

A.4.1 Lead

A.4.1.1 The determination of the amount of lead shall comply with the Standard Methods for Examination of Water and Waste Water, 16th edition (1985), prepared and published jointly by the American Waterworks Association, American Public Health Association and Water Pollution control Federation.

A.4.2 Tin

A.4.2.1 Apparatus

A spectrophotometer with 4 cm path length cells

A.4.2.2 Reagents, solutions and preparation

(1) Nitric acid, concentrated, d = 1.42
(2) Perchloric acid, 600 g/dm^3 solution
(3) Thioglycollic acid approximately 20 % (v/v) solution prepared by diluting 98 % thioglycollic acid with water
(4) Sulfuric acid, dilute, 25 % (v/v) solution
(5) Dodecyl sodium sulfate, 20 g/dm^3 solution prepared by dissolving 2 g of dodecyl sodium sulfate in 100 cm^3 of warm

water. The solution may lose its clarity on cooling; gentle warming will restore it.

(6) Toluene-3, 4-dithiol, 2 g/dm^3 solution prepared by dissolving 0.2 g of toluene-3, 4-dithiol(dithiol) or 0.28g of zinc toluene-3, 4-dithiol(zinc dithiol), in 5.0 cm^3 of 5N sodium hydroxide solution, Add 1 cm^3 of thioglycollic acid and dilute to 100 cm^3 with water. Filter if necessary. This solution should be prepared fresh daily.
Note: The life of this solution may be extended to about one week if it is stored under refrigeration conditions.

(7) Standard tin solution, 0.2 mg Sn/cm^3 prepared by dissolving 0.2 g of tin in 100 cm^3 of 50 % (v/v) hydrochloric acid and dilute with the same acid to 1 000 cm^3.

(8) Standard tin solution, 0.02 mg Sn/cm^3 prepared by diluting the 0.2 mg/ cm^3 standard solution (clause A.4.2.2.(7)) as required with 1+3 hydrochloric acid.

(9) Standard tin solution, 0.004 mg Sn/cm^3 prepared by diluting the 0.02 mg/cm^3 standard solution (clause A.4.2.2.(8)) as required with 1+3 hydrochloric acid.

A.4.2.3 Preparation of colour standards – standard graph

Into six cm^3 10 one-mark volumetric flashs transfer volumes of the 0.004 mg/cm^3 standard tin solution from 0 to 5.0 cm^3 increasing by stages of 1.0 cm^3. Treat each in the following manner:

(1) Dilute with water to about 6 cm^3, add two drops of the freshly prepared thioglycollic acid solution followed by 2 cm^3 of the dilute sulfuric acid and mix thoroughly.

(2) Cautiously add 0.4 cm^3 of the dodecyl sodium sulfate solution with constant swirling; avoid shaking, which creates foam. Continue to swirl the contents of the flash whilst adding 0.2 cm^3 of the toluene-3, 4 dithiol solution and heat to about 50°C for 5 minutes.

(3) Remove the flasks from the bath, cool and dilute the solution to the mark, stopper the flask and shake thoroughly. Transfer to a previously dried 4 cm cell and 15 minutes after the addition of the toluene-3, 4-dithiol, measure the optical density of each solution at a wavelength of 535 nm. Prepare a graph of optical density readings against microgrammes of tin present.

A.4.2.4 Determination

Evaporate a suitable volume of the test solution to dryness, and 2 cm^3 of the dilute sulfuric acid and evaporate to fumes of sulfur trioxide. Add concentrated nitric acid dropwise until the oxidation is complete. Cool, add 1 cm^3 of concentrated nitric acid followed by 0.2 cm^3 of perchloric acid and evaporate fumes of sulfur trioxide. Cool, transfer the contents to the basin quantitatively to a 10 ml one-mark volumetric flask and dilute to about 8 cm^3 with water. Add two drops of the freshly prepared thioglycollic acid solution and, with constant swirling, 0.4 cm^3 of the dodecyl sodium sulfate solution. Add 2 cm^3 of the toluene-3, 4-dithiol solution and heat to about 50°C for 5 minutes. Cool, dilute to the mark, stopper the flask and shake thoroughly. Transfer to a previously dried 4 cm cell and 15 minutes after the addition of the toluene-3, 4-dithiol measure its optical density at a wavelength of 535 nm, and read the amount of tin from the appropriate calibration graph (clause A.4.2.3).

If the amount of tin present per test is less than 20 μg, add a know volume of standard tin solution to the test solution and make a corresponding deduction at the end of the determination.

A.4.3 Cadmium

The determination of the amount of led shall comply with TIS 257, “Drinking water” : Part 2, “Analysis and testing” or the dithizone method in accordance with the Standard Methods for Examination of Water and Waste Water, 16th edition (1985), prepared and published jointly by the American Waterworks Association, American Public Health Association and Water Pollution control Federation.